

An Overview on Pulp and Paper Manufacturing Process and its Waste Treatment

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Abstract - The pulp and paper industry has a great impact in the world. It has been manufactured for ages and ages, it is still booming up as industry in small scale and large scale levels. Despite the fact that they produce printing and writing papers, paper rolls, packaging material etc. they also produce large amount of waste materials from their Industry by Manufacturing. This when left untreated leads to environmental pollution, harsh contamination and so on. As every industry has its own waste water treatment methods to recycle, reuse and reduce pollution. This Industry also has its own criteria to carry out the process of waste water treatment, yet it lags in being efficient in it. By the sources collected and compared with other kinds of industries it is listed that pulp and paper manufacturing industry is one of the top most industries to produce large volumes of waste water which has degradable organics at higher level. Hence this paper aims to study the manufacturing process, waste water components released and its effect on environment, the treatment methods carried out and how it can be improvised efficiently in forthcoming days.

Key Words: Contamination, Environmental impact, Manufacturing process, Methodology, Pulp and paper industry, Wastewater treatment.

1 INTRODUCTION

Waste water treatment is a process done to reduce the impact on environment by removing the contaminants from the waste water and converting it into an effluent which can also be directly reused. The waste water treatment is probably carried out in all sorts of industry because every industry's aim is to minimize the production of waste water or to recycle treated waste water within the production process [1]. The major industries to carry out the waste water treatment process are textile, pulp and paper industry, petroleum refining and petrochemicals, organic chemicals manufacturing, nuclear industry, mines and quarries, iron and steel industry, food industry [2]. Despite the fact that every industry listed above does waste water treatment, it is to be noted that paper and pulp industry produce large volumes of waste water that has degradable organics at higher level because of which it has created an environmental concern and it in turn created the processes to use the recycled water in the plants before they were disposed. But still this isn't enough and even more efficient process has to be done to overcome the waste water disposal in environment without causing contamination or pollution.

Pulp and paper industry is a material industry which being a major among industries contributes to water pollution. A small scale industry produces only pulp alone yet other large scale industries produce paper and pulp. The waste water treatment is done by doing various treatment methods such as primary clarification, secondary treatment and tertiary treatment in the industry. There are environmental effects to the society by the generation of pollution from paper and pulp mills. Clastogenic, carcinogenic, endocrinic and mutagenic are caused from high chemical pollutants which affect the aquatic Communities [3].

2 PULP MANUFACTURING PROCESS

Pulp is a commercial fibrous material that is obtained from bamboo, wood, bagasse (waste material) etc. by mechanical and chemical means. Pulping means disintegration of bulky fibrous material to small fibers. Pulping is a process in which the wood structure is broken into long cellulose fibers. There are mainly three methods of production of pulp: (a) Mechanical (b) Chemical (c) Semi chemical [4]. Mostly Kraft process is used to manufacture pulp, it is an alkaline process. To the cooking liquor, Na_2SO_4 is added so it is called Sulphate process. Pulp produced in this method gives high strength to the paper and makes the bleaching process easier [5] (Fig. 1).

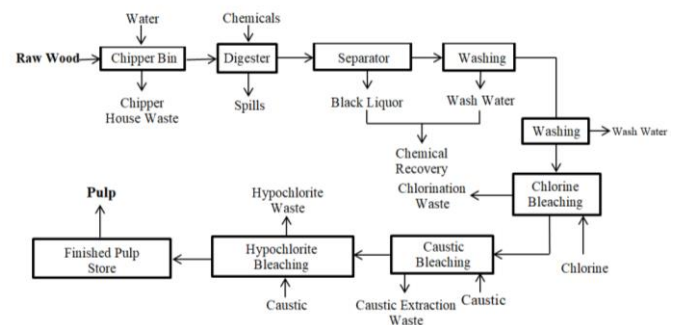


Fig.1 Paper Manufacturing

The raw material used in pulp and paper industry requires disintegration of bulky fibrous material to individual or small agglomerate fibers. The wood select should contain

long high in cellulose content and low lignin content where is ideal. Other sources like bagasse, hardwood, softwood, grass and reeds, straw cotton linters form Kenaf and Mesta.

Wood are collected and cut into logs. Then they are sent to the pulping industry where they have their own lumber yard where logs are debarked and made into chips. This chipping is done to ensure the flow and even cooking of the chips in the digesters.

Chipped wood pieces are cooked with digestion chemicals Na_2SO_4 at continuous digester tower is 25–30m tall. Volatilizing turpentine and non-condensable gases are used to preheat chips. To control digestion temperature, cooking liquor is withdrawn as side streams and circulated through heat exchanger. Lignin and other non-cellulosic content are removed from digester. Cooking time is about one and a half hours at 170°C . To avoid mechanical weakening of fibers, digested chips are cooled with recycled black liquor in a heat exchanger. Temperature is maintained at $140\text{--}180^\circ\text{C}$ and pressure at about 10 atm. Bottom temperature is maintained at 65°C [5, 6]. This process gives fibers that are undamaged and the non-fibrous wood was removed. The recovery process gives some of the digestive chemical from the spent cooking liquor.

2.1 Bleaching

Bleaching is a multi-stage process that refines and brightens raw pulp, removing brown colored lignin from the raw pulps. Bleaching agents, pH, temperature, duration, determines the stages. After these stages pulp is screened to remove contaminants like plastics and dirt.

In old days five stages Chlorine (C), Alkali Extraction (E), Chlorine dioxide (D), Second alkali extraction (E), and second chlorine dioxide treatment (D) [CEDED] process is done for bleaching which use chlorine to de-lignified process. Then ClO_2 chlorine oxide is substituted due to environment effects. Was pulp mill effluent containing chlorinated organic in final stage, sulphur dioxide (SO_2) is added as antichlor to resist ClO_2 reaction and maintain pH.

New techniques are chlorine free bleaching techniques which use enzymes O_2 , O_3 , H_2O_2 , and Ethylenediaminetetraacetic acid (EDTA). This new method eliminates acid bleaching process and acid washing which removes metals bound to cellulose.

Sulphite pulps are easier to bleach than sulphate pulps due to their low lignin content. Most paper grades uses

short bleaching sequences but removal of hemi-cellulose and lignin requires complex bleaching sequences to produce rayon, cellophane and so on. The effluent from this process is high because of high consumption of raw wood and water.

Brightening refers to bleaching of pulp. $\text{H}_2\text{O}_2/\text{Na}_2\text{S}_2\text{O}_4$, are brightening agents which destroys chromophoric groups without dissolving the lignin, chelating agents are called prior bleaching to neutralize metal ion exchange which forms colored salts or decomposition of H_2O_2 . The brightness of pulp depends on the species of wood [7].

3 PAPER MANUFACTURING

After pulp is produced then it is added with filler materials like alum, talc, etc. This is done in beater and these mixtures are blended well. Beater makes sure the mixture is knot free and breaks the bounded fibres in the pulp. Beater is a drum structured in which its wall consists of long blades/knives. The well mixed pulp is refined in Jordan. Jordan is a conical drum which has blades attached to the wall like beater. After attaining the required and the fibres are in same size it is diluted to paper consistency in a screening process which is passed through screens that separates knots and lumps. Then the pulp is spreader in travelling metal screens at wet end of the paper machine [8]. There pulp sheets are pressed by the series of rolls which squeezes out water and air until the fibre is 40–45%. Then the sheets are floated through hot air driers till its consistency reaches 90–95%. The long sheets are cut into pieces and stacked into bales. The bales are compressed, wrapped and packed (Fig. 2).

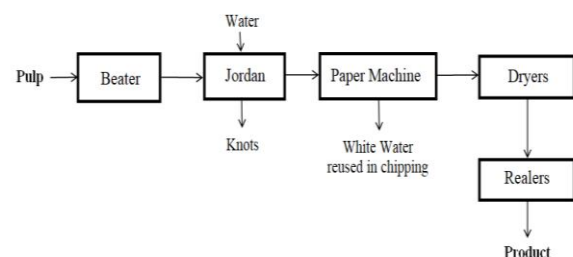


Fig.2 Paper Manufacturing

4 MAJOR POLLUTANTS

The paper and pulp industry utilizes large amount of energy and water for the production which in turn results in waste generation also. The waste generated from manufacturing process steps harms the environment as pollutants. The

different sources for the pollutants are chemical pulping process, bleaching, waste water treatment, power boiler, evaporator, recovery furnace, Calcining [9] :

4.1 Chemical pulping process

When wood or other fibrous feedstock's are converted into a product mass by dissolving lignin which does binding, it releases major pollutants during this whole pulping process such as VOC's [terpenes, alcohol, phenols, methanol, acetone, chloroform, Methyl Ethyl Ketone (MEK), reduced sulphur compounds (TRS), organo-chlorine compounds].

4.2 Bleaching

This process is done to lighter and whiten the pulp. As the residual lignin is removed by chlorinated organic compounds which in the environment are in large amounts by this process and the major pollutants released are VOC's (acetone, Methylene chloride, chloroform, MEK, chloromethane, trichloro ethane).

4.3 Waste water treatment plant

By this treatment the suspended solids, organic matter, toxicity, colour are removed. But still pollutants that are released in environment are VOC's (terpenes, alcohols, phenols, methanol, acetone, chloroform, MEK).

4.4 Power boiler

As the residues such as wood, bark burnt in separate power boiler generates steam which has harmful pollutants and is considered to be causing impact in the environment because it has pollutants such as SO_2 , NO_x , fly ash, coarse particulates.

4.5 Evaporator

This evaporator source during the process produces evaporator non condensibles such as (TRS, volatile organic compounds: alcohols, terpenes, phenols).

4.6 Recovery furnace

It is a process where recovery of chemicals for white liquor is done from which the release of major pollutants such as fine particulates, TRS, SO_2 , and NO_x are obtained.

4.7 Calcining (lime kiln)

Lime kiln is done to convert lime mud to lime by using heat, airflow and this is known as Calcining. The obtained lime is

again used in recaust process. Through this process Fine and coarse particulates are the major pollutants obtained.

5 WASTE WATER TREATMENT

Waste water Treatment is a process of recovery of the water and removal of undesired substance from the water before leaving into the environment. Treated waste water can be used in many ways such as coolant water, wash water (Fig. 3). The waste water treatment consists of three stage of treatment process and they are primary, secondary and tertiary [10].

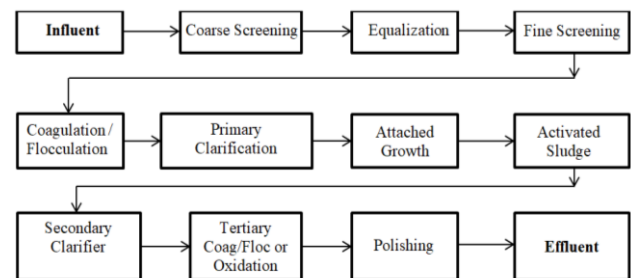


Fig.3 Wastewater Treatment

5.1 Primary Treatment

Coarse solids, fine solids and suspended solids are removed by automatic bar screen, static fine screen and chemicals. Solids replace biomass which breaks down the solids for removal of other contaminants. Solids are separated by dissolved air floatation clarifier and skimmed off from waste water.

5.2 Secondary Treatment

Two stage biological systems are used in this treatment and firstly it has [TFT] Trickling Filter Tower, Secondly it has [EAS] Extended Aeration System. The TFT helps in growth of biomass slime layer. There are 2 types of growth.

- i). Inner layer: It is an anaerobic biomass.
- ii). Outer layer: It is an aerobic biomass.

The waste water is sprayed from the top onto the media. The TFT cools down the temperature for bacterial activity. The organic pollutants are break down by the aerobic biomass which utilises oxygen. So the wastewater gets clarified in the secondary clarifier.

5.3 Tertiary Treatment

Coagulation or oxidation process is the work to be done to remove the high level of recalcitrant contaminants if present. The treatment water has suspended solids which can be removed by polishing with a Multi Media Filter (MMF). This filter uses various sizes of anthracite and sand to remove these solids.

6 DISPOSAL METHOD

After treating the waste water sludge is formed in the processes so there should be a proper disposal methods followed by their characteristics. Integrated solid waste management of pulp and paper mills are done through anaerobic digestion, land applications, composting and thermal processes such as incineration/combustion, pyrolysis, steam reforming, and wet oxidation [9].

6.1 Anaerobic Digestion

This process is a cost efficient way due to the high-energy recovery. Industrial wastes which are high in organic content and digestible wastes are suitable for this method like paper sludge and wastewater treatment plant sludge.

6.2 Composting

This method is appropriate for sludge, like paper fibres and organic materials. The wastes are stabilized by microorganisms with marginal carbon loss. Humus-like material is the end product of composting that can be used for house garden, greenhouse and agriculture.

6.3 Land Application

This method is mostly preferred disposal method, especially for the acidic soil due to CaCO_3 content in sludge. This method is widely used in the United Kingdom and Northern Europe. In olden days, dewatering and/or incineration treatment are done to the sludge in order to reduce volume.

6.4 Incineration (Combustion)

Incineration is combined with power and steam generation is one of the most common methods in Europe, mainly for wastewater treatment plant sludge. Mostly, energy deficiency is caused by water and ash content of most sludge. Final disposal is done by Fluidized bed boiler technology which is becoming the best solution for the final disposal of paper mill wastes in order to give successive thermal oxidation of high moisture wastes, high ash.

6.5 Pyrolysis

In the absence of oxygen and under high temperature, organic wastes are converted to gaseous and liquid phase. This is a substitute method for incineration and landfill. High organic content wastes such as wood, petroleum, plastic waste are disposed in this method. However this method is not sufficient for pulp and paper mill waste.

6.6 Steam Reforming

This method is used for sludge treatment. This is considered as an emerging technology for paper sludge. It is a novel combustion technology that carries out in a steam reforming reaction system.

6.7 Wet Oxidation

Under high temperature and pressure, organic compound that are in solid or liquid form is transferred into water which contacts with an oxidant. During this process, waste and water mixture is carbonized and its fuel value is increased equivalent to medium-grade coal. Now it does not cause any air emission when combusted without flame or smoke. Like steam reforming, this method is considered as an emerging technology.

7 IMPACT IN WATER BODIES

Solids, nitrogen, phosphorus, lignin, alcohols, chelating agents, chlorates, transition metal compounds discharged from waste water can cause eutrophication, change in ecosystem when released in water bodies.

Toxic Weighted Pound Equivalents (TWPE) in water are highly discharged by the pulp and paper industry as it has compounds like hydrogen sulphide, dioxin, manganese and their likely compounds [11].

7.1 PROSPECTS OF SOLUTION

Though all the unchanged and discharged matters cannot be made good, there are few ways to reduce the adverse effect.

1. The pulping and bleaching process can use less amount of damaging agents to decrease the contamination.
2. The chemical oxygen demand (COD) can be removed in the waste water treatment process by pre-treating it

with coagulation kind of methods and thus the aquatic pressure is reduced.

3. Bioremediation ponds help actively to reduce pollutants.
4. The end of waste water treatment that is the effluent can be recycled and burnt to prevent the water pollution [12].

8 CONCLUSION

As we know, the importance of pulp and paper industry is vividly high with the growth in population and usage. The manufacturing process, waste water treatment, pollution in water bodies discussed in this paper helps us to know that the need of booming technology is a must need to develop the industry in an eco-friendly efficient manner possibly, so that the pulp and paper industry doesn't be the top in discharging high amount of contaminants in air and water bodies as it collapses the natural eco system by gas emissions to dead aquatic organisms.

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